Voyager Bulletin

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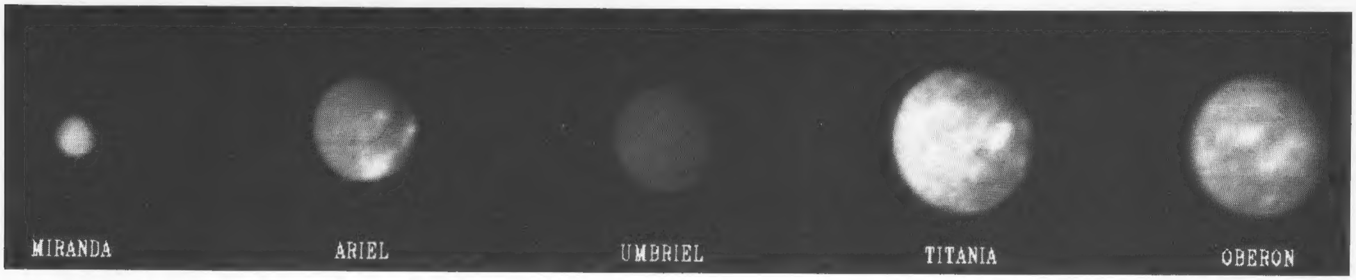
Many Moons . . .

As Voyager 2 closes in on Uranus, the number of known moons is rapidly increasing. In addition to the small moon discovered in December, eight additional small moons – including two flanking the epsilon ring – have been confirmed in long-exposure images designed to search for such objects. Six are 30 to 50 kilometers in diameter, and orbit between the outermost known ring (the epsilon ring) and the heretofore innermost known moon Miranda. All are also inside Voyager's trajectory. The two moons near the epsilon ring are called "shepherding" moons because of the theory that such moons "herd" ring particles between them. Voyager scientists expect to find more Uranian satellites, both in and around the rings, during the next two weeks of the flyby.

For now, all will carry official numerical designations, until the nomenclature committee of the International Astronomical Union recommends names for them and names are approved at the IAU Congress in several years. Until then, for example, the first Uranian moon discovered in 1986 will be designated 1986 U1.



This "family portrait" of Uranus' five largest moons was compiled from images sent back January 20 by Voyager 2. The pictures were taken through a clear filter from distances of 5.0 million to 6.1 million kilometers (3.1 million to 3.8 million miles). The relative sizes and reflectivities of the satellites are shown. From left, in order of decreasing distance from the planet, they are Miranda, Ariel, Umbriel, Titania and Oberon. The two largest, Oberon and Titania, are about half the size of Earth's moon, or roughly 1,600 kilometers (1000 miles) in diameter. Miranda, the smallest of the five, has about one-quarter to one-third the diameter. Even in these distant views, the satellites exhibit distinct differences in appearance. On average, Oberon and Titania reflect about 20 percent of the incident sunlight, Umbriel about 12 percent, Ariel and Miranda about 30 percent. Ariel shows the largest contrast on its surface, with the brightest areas reflecting 45 percent of the incident sunlight, the darkest areas about 25 percent. All five satellites show only slight color variations on their surfaces, with their average color being very nearly gray.

Engineering Update

The trajectory correction maneuver scheduled for January 19 was canceled since the flight path was deemed satisfactory without further refinements. Deletion of the maneuver allowed more tracking data to be gathered for final updates to the timing and pointing of critical observations near closest approach on January 24.

The final pre-encounter torque margin test on January 20 showed the azimuth and elevation actuators of the steerable scan platform to be in good health. The azimuth actuator had caused the platform to stick shortly after the spacecraft's closest approach to Saturn in August 1981, and several years of analysis and testing on the ground and in-flight followed. Torque margin tests are run periodically to detect any degradation in actuator operation. Had such degradation been apparent, plans had been developed to point the platform-mounted instruments during the most critical near-encounter sequence by rolling the spacecraft rather than moving the scan platform. Four optical instruments ride on the platform.

A problem in one of the spacecraft's onboard computers was worked around on January 20 by transmitting a patch to bypass a discrete bit in memory of the secondary Flight Data Subsystem – the unit that performs image data compression. The problem, inversion of one bit in one word of the memory, caused apparent streaking of the images as they were displayed. The cause of the problem was apparently a single word memory failure. All data was recorded on Earth, and all information is expected to be recovered. Only imaging data was affected.

Deep Space Network

The Uranus encounter presents an unprecedented challenge in deep space communications. The Voyager X-band radio signal, for example, will be less than one-sixteenth as strong as it was at Jupiter in 1979, due to the enormous distance the spacecraft has travelled. NASA's Deep Space Network (DSN), operated by the Jet Propulsion Laboratory, has tracked and communicated with U.S. deep space probes since 1962.

DSN stations are located around the world in multiantenna complexes at Goldstone in California's Mojave Desert; near Madrid, Spain; and near Canberra, Australia. The three complexes are spaced at widely separated longitudes so that spacecraft can be in continuous view as the Earth rotates.

The DSN has just undergone a major upgrade adding, among other things, new 34-meter antennas and automatic network monitor and control. A new baseband signal-combining system called "arraying" has also been developed to optimize the weak telemetry signal received at two or more antennas. Each station uses its 64-meter (210-ft) antenna and 34-meter (112-ft) antenna for deep space communication. (The sizes refer to the antenna dish.) In addition, high-efficiency 34-meter antennas have been added at Goldstone and Canberra, and another is scheduled to begin operations at Madrid in March 1987.

The structure of a 64-meter antenna is 21 stories high and weighs nearly 8,000 U.S. tons. The rotating portion, which weighs more than 3,500 U.S. tons, floats and moves on a thin film of hydraulic oil about 0.2 millimeters thick. Despite its size, the antenna, with its complex electronic equipment and unique mechanical systems, is a precision instrument capable of communicating with spacecraft at the edge of the solar system. The maximum tracking velocity is 0.25° per second. Pointing accuracy is about 0.005°.

In addition to the giant antennas, signal processing centers at each complex house equipment for transmission, reception, data-handling, and interstation communication. The downlink radio frequency system includes cryogenically cooled, low-noise amplifiers.

Spacecraft commands are sent from JPL to the ground stations via data lines, microwave links, and satellite links. At the stations, the uplink to the spacecraft operates at the S-band radio frequency (2,113 megahertz). The 64-meter antennas have 400-kilowatt transmitters which are normally operated at 60 kilowatts for Voyager.

The Voyager data rate is shrinking due to the increasing distance between Earth and the spacecraft, so modifications have been made both on the ground and on the spacecraft. At Jupiter, 5 AU* from the Sun, the maximum data rate was 115.2 kilobits per second (kbps) using the spacecraft as built and the 64-meter tracking antennas. At Saturn, at 10 AU, the maximum data rate dropped to the 44.8 to 29.9 kbps range, even with the addition of some antenna arrays. At Uranus, at 20 AU, the maximum data rate range is 21.6 to 14.4 kbps. The spacecraft uses a more efficient data encoding scheme and image data is compressed by transmitting only the difference in brightness between adjacent picture elements (this technique, called image data compression, requires less than half as many bits to transmit an image). In addition, the DSN arrays its antennas on a regular basis for Voyager, and with the negotiated support of the 64-meter Parkes Radio Astronomy Observatory (operated by the Australian Central Science and Industry Research Organization), the Canberra complex can array four antennas. At Neptune, the data rate is expected to hold steady at 21.6 to 14.4 kbps by enlarging the 64-meter antennas to 70 meters, adding a high-efficiency 34-meter antenna in Madrid, and negotiating support for short periods from other agencies.

At the Uranus encounter, all DSN antennas at each longitude will be arrayed, so that their combined collecting areas will increase the amount of signal captured and thus improve the potential for high-rate low-error data return.

Arraying the antennas almost doubles the collecting area and increases the expected signal strength to one-half – instead of one-fourth – the Saturn level when Voyager 2 reaches Uranus.

Australian activities will be critical to encounter support, because the high southern (-23 degree) declination of Voyager 2 will result in long (up to 13 hours) spacecraft view periods at Canberra and Parkes. Large distances between the Parkes and Canberra antennas decrease the risk of lost data due to local weather conditions, as X-band radio signals are very sensitive to atmospheric water vapor.

The combined Canberra–Parkes facilities will obtain the critical closest-approach imaging and science data for Uranus and all its satellites on January 24, in addition to data recorded on the spacecraft and played back over the next several days. This Canberra–Parkes array is expected to obtain various telemetry data during closest approach and all radio science data during the critical Uranus and ring occultation periods on January 24, encounter day.

**An astronomical unit (AU) is the distance between Earth and the Sun – about 150,000,000 km (93,000,000 mi.).*

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